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PRINCIPAL INVESTIGATOR: Eric A. Mann, M.D., Ph.D.

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Although dysphonia is a recognized consequence of acute vocal abuse, associated changes in vocal cord anatomy and function are not well understood. To document these presumed effects of acute vocal abuse, we prospectively obtained videostroboscopic exams and serial voice recordings on U.S. Army drill sergeants during a vocally demanding training exercise. High quality digital audio recordings of sustained vowel production were obtained from 36 drill sergeants at baseline (following a 2 week period of relative voice rest) and daily during the first five days of a new training cycle. Computer-based acoustical analyses of the recorded voice signal was performed using Kay Elemetrics Multidimensional Voice Analysis System (MVAS). Laryngeal videostroboscopic exams were also obtained at baseline and following five days of training, and were rated independently by two experienced speech pathologists. Voice questionnaires outlining individual vocal hygiene characteristics and pertinent medical history were completed by all subjects. Analysis of videostroboscopic recordings revealed significant increases in vocal fold edema ($p<.004$), erythema ($p<.02$), edge irregularity ($p<.002$), and decreases in vocal fold mucosal wave ($p<0.05$) and amplitude of excursion ($p<.004$) following the five day training period. Although the majority of subjects demonstrated no consistent alterations in vocal acoustic parameters, a subgroup of drill instructors exhibited significantly increased measures of vocal perturbation (shimmer, jitter). The association of abnormal videostroboscopic exams and acoustic analysis findings with various patient demographics and vocal hygiene characteristics will be discussed.

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I. INTRODUCTION

Leaders of small military units readily admit to deterioration of voice quality or even loss of voice due during training and field exercises. Degradation of voice quality can severely impair field communication and adversely affect a leader's ability to safely, effectively command his or her unit. Frequently, such voice changes resolve only after prolonged voice rest, and repeated episodes of abuse have led to permanent vocal cord pathology and socially unacceptable voice quality in some individuals.

Anatomic changes in the vocal cords following periods of acute and chronic voice abuse have been documented in the literature to include edema, nodules, polyps, contact ulcers, hemorrhage, and scarring [1,2]. No studies to date, however, have addressed the chronology of voice and vocal cord changes that occur during voice abuse. A clear understanding of the pathophysiological changes that occur during an episode of voice abuse may ultimately be helpful in developing strategies to combat voice impairment and vocal cord injury.

To document vocal cord pathological changes, clear visualization of the vocal cords is essential. The standard office evaluation in the past relied on "indirect" visualization of the larynx using a laryngeal mirror. The reflected image of the vocal cords is small but adequate for diagnosis of gross anatomic or functional changes. Flexible fiberoptic endoscopes passed transnasally are also valuable in evaluating patients with hyperactive gag reflexes and anatomic configurations which preclude a thorough mirror exam (e.g. an overhanging epiglottis or anteriorly-situated larynx).

The relatively recent addition of videostroboscopy as a diagnostic tool has dramatically improved the otolaryngologist's ability to identify vocal cord pathology [3]. Stroboscopic technology allows the examiner to slow the apparent vibration of the vocal cords to a level which

is perceptible by the human eye. Thus, detailed evaluation of the vibratory wave of the vocal folds and detection of subtle anatomic and functional changes is possible. One can observe the effects of vocal fold edema, polyps, nodules, scar tissue, and hyperfunction on the vibratory pattern of the larynx. Furthermore, a permanent record of the examination is produced for detailed analysis and comparison to subsequent examinations. Sataloff et al.[4,5] demonstrated that the addition of videostroboscopy in the evaluation of hoarse professional speakers had proven helpful in 47% of individuals and actually resulted in a change of diagnosis in 18% of these cases. Woo et al.[6] observed that videostroboscopy contributed significant diagnostic information in 27% of cases and led to change in diagnosis in 10%. Thus, videostroboscopy has proven usefulness in the evaluation and documentation of vocal fold pathology.

Another tool available for the study of voice quality is acoustic analysis of the voice signal. It is generally accepted that selected features of the acoustic voice signal reflect important characteristics of vocal fold vibration. The fundamental frequency of the acoustic wave is directly related to the period of vocal fold vibration, and irregularities in vocal fold vibration are reflected in measures of period and amplitude perturbation (i.e., jitter and shimmer, respectively). Thus, acoustic analysis of these parameters can be used to quantify variations in vocal performance, and presumably these should be correlated with measures of vocal fold vibration based on direct viewing of the larynx as obtained with videostroboscopy. The combination of acoustic measures with videostroboscopic measures is an ideal marriage[2]. The stroboscopic images help explain the source of the acoustic analysis findings, while the acoustic parameters help to quantify the qualitative observations from the stroboscopic recordings Additional validity is given to acoustic measures of voice performance because they are well correlated with perceptual judgments of voice quality. Acoustic analysis of the voice is particularly appealing

because of the objective nature of the measurements, the ease of data acquisition and the availability of computer-based methods of automated measurement.

There has been limited research into the effects of prolonged or strenuous voice production that involves acoustic analysis, although studies of this type can now be found in the voice literature[7]. U.S. Army Drill Instructors are an extremely high risk population for voice pathology because of their duties require prolonged periods of loud talking and yelling while instructing and disciplining troops. Because their schedule consists of cycles of intense training with intervening rest periods of several weeks, drill instructors are a useful model for studying vocal abuse. The intent of this project was to provide the first detailed chronologic record of laryngeal tissue alterations and acoustical voice changes which occur during a period of acute voice abuse and may lead to impairment of drill instructor performance. Furthermore, attempts have been made to identify "risk" factors such as specific voice behaviors, underlying medical conditions (e.g.. gastroesophageal reflux) and dietary habits (caffeine intake), which may predispose an individual soldier to the deleterious effects of vocal abuse.

II. Body

A. General Overview of Experimental Methods

The study population consisted of 44 active duty drill instructors from four designated companies at Fort Jackson, S.C., who were actively involved in the training of new military recruits. Exclusion criteria included a known history of laryngeal surgery, known laryngeal pathology, or the use of inhaled or oral steroids. Enrollment of the instructors into the protocol occurred just prior to the commencement of an intensive six week training cycle. For at least two weeks prior to enrollment in the protocol, the subjects had been free of training responsibilities requiring any strenuous voice activities.

After obtaining informed consent for participation in the study, each of the subjects was asked to complete a medical history questionnaire (Appendix I) and a voice case history form (Appendix II) to identify relevant medical conditions and/or abusive voice behaviors associated with their duties. A baseline laryngeal videostroboscopic examination and voice recording were obtained during this initial session (described below). For the purposes of acoustic analysis, the 44 subjects were subsequently stratified into three groups for which voice recordings were obtained at the same time of day for five consecutive work days to control for the possible short term effects of extensive vocal use during the day:

Group	Voice Recording Time
I	0600-0700 hr
II	1100-1200 hr
III	1600-1700 hr

A followup videostroboscopic examination was performed following the final voice recording for comparison to the videostroboscopic baseline examination.

B. Laryngeal Videostroboscopic Examinations

Videostroboscopic examinations of each subject were performed during the initial evaluation (Day 0) and following the final voice recording (Day 5) to document any visible changes in the subjects' laryngeal anatomy and function during the period of strenuous voice activity. Recordings were obtained using the Kay Elemetrics RLS Stroboscopy System (Model 9195). Briefly, following application of topical anesthetic spray (Cetacaine) to reduce the subject's gag reflex, a rigid 70° telescope introduced transorally to visualize the larynx using a stroboscopic xenon light source. A super VHS (sVHS) recording of the subject's larynx was obtained under the following conditions:

1. Quiet respiration
2. Sustained "eee" at comfortable pitch and loudness
3. High-pitched "eee"
4. Low-pitched "eee"
5. Loud "eee"
6. Soft "eee"
7. Glide from low to high pitched "eee"

Three patients were unable to tolerate the transoral rigid endoscope due to hyperactive gag reflexes and were examined transnasally with an Olympus flexible fiberoptic nasopharyngoscope.

C. Digital Voice Recordings

High quality voice recordings were obtained on each subject at baseline (Day 0) and during each of the next five consecutive work days at the same time each day depending on group assignment. Recordings were obtained using a Panasonic SV-3900 digital tape recorder with a Shure 565SD-CN cardioid dynamic microphone and Rane MS-1 microphone preamplifier. All recordings were obtained in the same sound-treated audiometry booth. In an effort to standardize recording conditions, a lip to microphone distance of 8 cm was used in all patients. For each recording session, the subjects stated their name, last four digits of their social security number, the date and time, and their vocal abuse rating (Appendix III). They next produced a sustained "ahh" for a period of 5 seconds at a conservational loudness level and comfortable pitch and recited the following speech sample: "The top of the pot is very hot."

D. Data Analysis

Videostroboscopic recordings were evaluated by two independent raters using a customized rating scale which examined vocal fold closure, glottal gap, vocal fold edges, hourglass configuration, amplitude of excursion, mucosal wave, phase symmetry, edema, and erythema (Appendix IV). Both raters were speech pathologists who were experienced in videostroboscopy. Both raters practiced use of the customized rating scale until they understood and consistently applied the ratings to non-experimental recordings of videostroboscopic recordings of both flexible and rigid laryngeal examinations. Forty-three of the forty-four subjects had both pre- and post videostroboscopic recordings available for rating. These 86 total recordings were dubbed randomly onto a second tape for evaluation by the raters who were

blinded with respect to subject identity. Duplicate recordings of ten out of the 86 recordings were inserted randomly throughout the second tape to assess intra-rater reliability.

Acoustic analysis of voice recordings was carried out with the Kay Elemetrics Multidimensional Voice Analysis System (MVAS). The analysis procedure first involved digitizing to the computer a three-second sample of the sustained "ah" using a sampling rate of 50 kHz. Automated software routines were then used to extract several different measures that represent the acoustic correlates of temporal stability of vocal fold vibration and perceived voice quality. A subset of 14 measures was initially considered in the analysis process (see Appendix V). The 14 acoustic measures from the Kay Elemetric data files were automatically read in to a statistical spreadsheet (Minitab 10.0). This same spreadsheet also was employed for storage and analysis of the results of the stroboscopic evaluations and coding subject characteristics and history (e.g. smoking, age, gender, vocal use rating).

Multiple correlation analysis indicated that several of the acoustic measures were strongly correlated with one another (Table I). This was to be expected, since within the MVAS, certain measures represent subtle variation of the same basic process. For example, three measures evaluate pitch period perturbation using different duration smoothing windows. Because of this and the high correlations between measures, subsequent analyses were restricted to a subset of four measures: fundamental frequency, percent vocal jitter, percent vocal shimmer, and voice turbulence index. Fundamental frequency is the reciprocal of the average period of vocal fold vibration, and it averages about 120 Hz in adult males and 220 Hz in adult females. Percent vocal jitter and shimmer reflect respectively the average period-to-period variation in cycle duration and amplitude. The voice turbulence index is an average ratio of the inharmonic energy in the 2800-5800 Hz band to the harmonic energy in the 70-4500 band. Normative data on each

of the acoustic measures are available in the literature and through Kay Elemetric's testing with their own system (Appendix V). Abnormal levels of jitter exceed 1.04 %, shimmer exceeds 3.81 %, and turbulence ratio exceeds 0.061 %.

E. Videostroboscopic Examination Results

The results of the videostroboscopic rating reliability were obtained using the Pearson R correlation coefficient test. This demonstrated inter-rater reliability of .51 and intra-rater reliability of .67 (.62 for rater 1 and .76 for rater 2). The reliability scores were somewhat lower than the desired level (greater than .70) because of the quality of some of the laryngeal examinations. Poor resolution of the larynx occurred in some cases making it difficult to assess vibratory and structural parameters. Raters indicated those video clips with poor imaging on their rating sheets and theses image ratings were excluded from the analysis.

A t-test was applied to determine whether scores from examinations at baseline significantly differed from those obtained following the five day study period. The results indicate that vocal fold edge irregularity ($p<.0002$), erythema ($p<.017$), and edema ($p<.004$) were significantly increased and the amplitude of excursion ($p<.004$) and mucosal wave ($p<.05$) were significantly decreased following the five day study period. An illustrative subject's (L.K.) pre- and post- laryngeal exams are presented in Figure 1. Note the increased edge irregularity, increased vocal fold edema and vascularity following five days of strenuous voice activity.

These findings are likely the result of increased laryngeal valve resistance (i.e., increased laryngeal muscle tension) and the increased airway pressures required to produce loud speech during training exercises. The laryngeal mucosa, especially the glottal edge, becomes inflamed, swollen and irritated, and these changes lead to altered vocal fold vibration and diminished voice quality. Over time, these changes could cause drill instructors to develop compensatory voice

behaviors (e.g.. alteration of fundamental frequency, increased laryngeal tension) to overcome the physical effects of strenuous voice use.

F. Voice Acoustic Analysis Results

Acoustic analysis indicated that in the preponderance of cases vocal performance fell within normal limits. This may be seen in Figures 2, 3 and 4 which show frequency histograms for jitter, shimmer and voice turbulence across all subjects and days of testing. The vertical line on each histogram indicates the approximate upper limit for normal performance. Average fundamental frequency was 120 Hz for male subjects (n=39) and 196 Hz for female subjects (n=5). These values are within expected normal limits although slightly less than expected for the female subjects (Figures 5 and 6). Fundamental frequency was of primary interest here with respect to how it may co-vary with the other three measures which are assumed to reflect quality of vocal performance.

Statistical analyses of acoustic results initially focused on possible time series effects related to prolonged strenuous use associated with drill instructor training. A general linear model was employed to perform three multi-way analyses of variance with jitter, shimmer, and the turbulence index serving as the criterion or dependent measures; and day of testing, vocal use rating, and smoking as the factors. F-tables and summary means associated with these analyses are provided in Table II. Smoking was found to be a significant factor for all three acoustic measures ($p < 0.05$), each showing greater mean levels for individuals who smoke. Additionally, for the voice turbulence index, day of testing and vocal use rating were statistically significant. Higher vocal use ratings showed elevated turbulence. Surprisingly the turbulence index tended to decrease through the course of training. As discussed below, this may be related to vocal abuse effects in some subjects which resulted in increased vocal fold mass due to laryngeal

edema.

As might be expected from the frequency histograms in Figure 2, 3, and 4, many subjects' perturbation values remained within normal limits throughout the course of training. In order to evaluate training effects in greater detail, time series analyses were performed in which subjects showing abnormal jitter measures on Day 1 (n = 8) were excluded. Figures 7, 8, and 9 show box-and-whisker plots for the six days on the remaining 36 subjects. As indicated by the changes in variability and pattern of outliers, it can be surmised that particular individuals showed more pronounced effects through the course of training. Five subjects showed jitter values that exceeded one percent on Days 2-6, and these were selected for more in-depth analyses. In each of these five cases clear evidence of increased vocal irregularity could be seen throughout the course of training. Data on one of these subjects (L.K.) are given in Figure 10,11, and 12. It is notable that this subject showed reduced voice turbulence over the course of training. Stroboscopic evaluation of this subject showed increased redness and edema at the end of training. This is consistent with increased vocal fold mass which could partially explain the reduced voice turbulence.

G. Assessment of Voice Instruction at the Drill Instructor School

During the data collection phase of the protocol at Ft. Jackson, a review of the current instructional materials regarding the "command voice" for students at the drill instructor school was undertaken. Discussion with the instructors at the school and review of the instructional materials (FM22-5, Chapter 1, Section II and glossary) by a speech pathologist led to the following findings and recommendations:

1. A total of only two hours of course instruction time were allotted for the didactic and practice sessions related to command voice. During this period the student is expected to master proper posture, volume, inflection, snap, distinctiveness, and cadence. These are complex motor skills which cannot realistically be learned in such a limited time.

2. No specific instruction was given on how to project the voice over various distances.

3. Although brief references to posture and correct adjustment of mouth/throat with respect to generating loudness were made, no specific instruction was given on how to accomplish these behaviors.

4. The importance of diaphragmatic breathing to generate proper volume is mentioned in the instructional materials, but no clear visual aids or demonstrations of the location, function and proper use of this muscle were presented. This was particularly evident when we interviewed drill instructors who knew the term "diaphragmatic" breathing but did not understand how to perform it.

Given the key importance of the voice in the duties of drill instructors (and military leaders in general), an increased emphasis on learning proper vocalization techniques and applying these techniques in the performance of their duties is recommended. A suggested lesson plan is enclosed in Appendix VI for consideration by the Drill Instructor School.

III. Conclusions

In general, the present results suggest that both videostroboscopic examination and acoustic measures of voice perturbation can provide an efficient means to document and quantify adverse effects of strenuous voice use/abuse on vocal cord anatomy and function. In particular, videostroboscopy revealed significant increases in vocal fold edema, erythema, edge irregularity

and significant decreases in mucosal wave and amplitude of excursion when the study group was examined as a whole during the training exercise. Acoustic analysis of the voice signal, in contrast, revealed no significant deviation from normal ranges for most subjects during the study period. However, a subset of drill instructors developed abnormal values for jitter, shimmer, and noise-to-harmonic ratio over the course of the study period. There was a significant association between smoking and vocal use rating and the development of abnormal voice acoustic parameters over time. Finally, review of the drill instructor school curriculum revealed deficiencies in educating soldiers to understand and effectively use proper vocalization techniques which maximize vocal performance while minimizing potential injury to the larynx.

Future studies might include assessment of a group of drill instructors receiving an intensive course on proper vocalization techniques compared to drill instructors receiving the standard educational curriculum. Comparison of videostroboscopic examinations and acoustic voice signals between the two groups would likely validate the importance of voice education in leadership positions. Clearly, since smoking appears to be an important risk factor contributing to adverse vocal effects associated with strenuous voice use, a study comparing the development of voice/vocal fold changes before and after smoking cessation would be another area of interest with obvious treatment implications. Further study of acute and chronic vocal abuse could ultimately lead to educational and therapeutic strategies to improve vocal performance in both the training and combat settings.

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Figures

Figure 1. Video-endoscopic photograph of subject L.K.'s larynx at baseline (A) and following five days of strenuous voice activity (B). Note increased vascularity, edema, and edge irregularity in (B).

Figure 2. Histogram across subjects and days showing the frequency of occurrence of different levels of vocal jitter. The vertical line indicates the cutoff for abnormal levels.

Figure 3. Histogram across subjects and days showing the frequency of occurrence of different levels of vocal shimmer. The vertical line indicates the cutoff for abnormal levels.

Figure 4. Histogram across subjects and days showing the frequency of occurrence of different levels of voice turbulence. The vertical line indicates the cutoff for abnormal levels.

Figure 5. Fundamental frequency descriptive statistics for male subjects.

Figure 6. Fundamental frequency descriptive statistics for female subjects.

Figure 7. Box and whisker plot showing jitter levels across the six days of training for all subjects (n = 36) who were within normal limits on the first day.

Figure 8. Box and whisker plot showing shimmer levels across the six days of training for all subjects (n=36) who were within normal limits on the first day.

Figure 9. Box and whisker plot showing noise-to-harmonic ratio for subjects across the six days of training for all subjects (n=36) who were within normal limits on the first day.

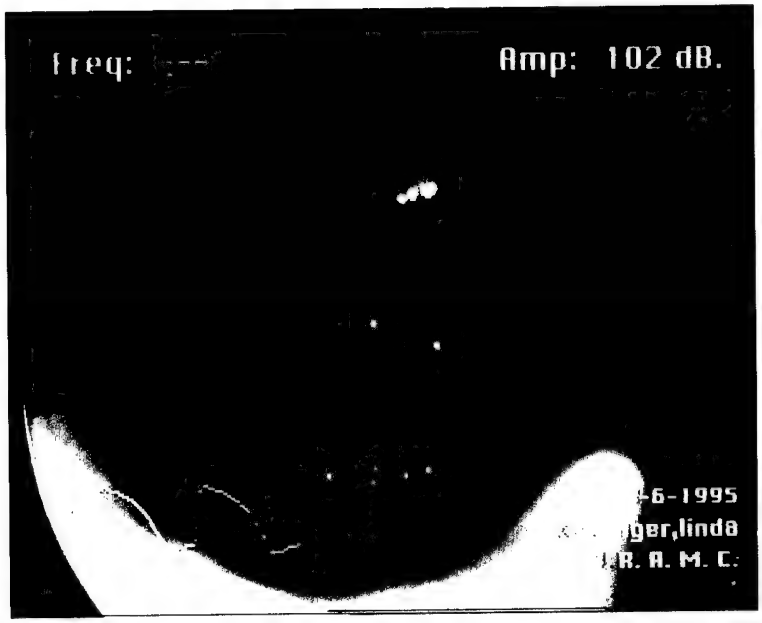
Figure 10. Percent jitter for Subject L.K.

Figure 11. Percent shimmer for Subject L.K.

Figure 12. Voice turbulence for Subject L.K.

Figure 1.

A)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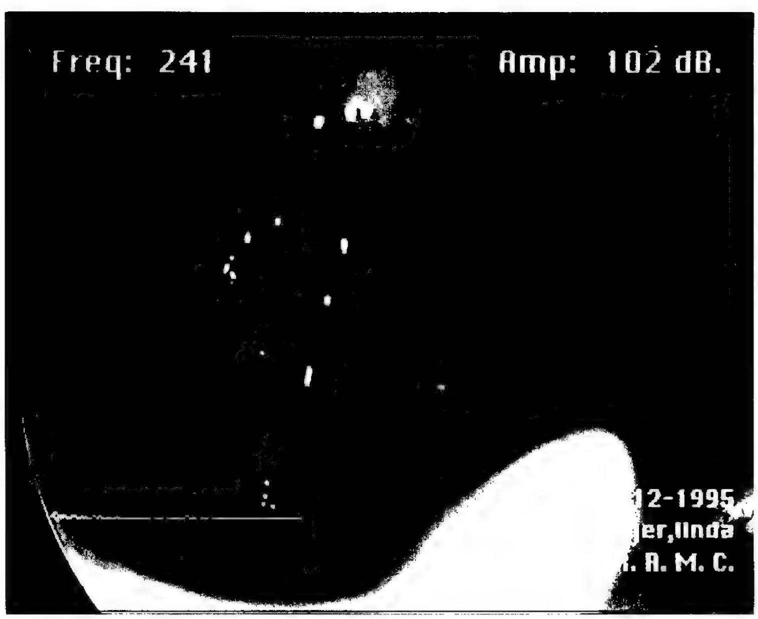
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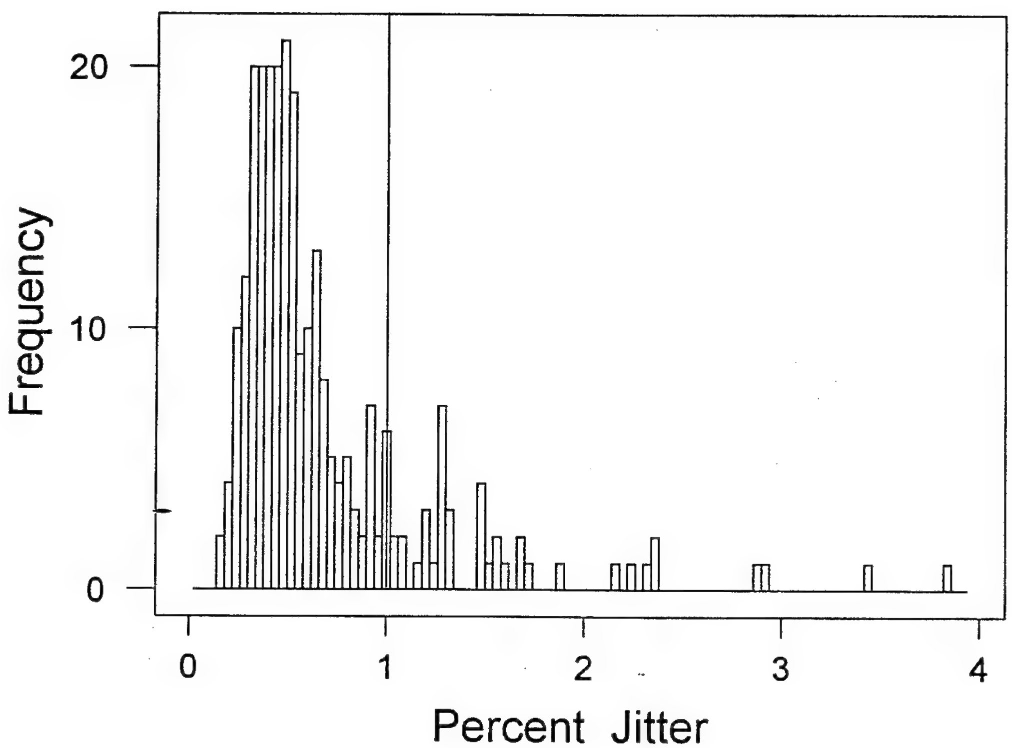
Figure 2



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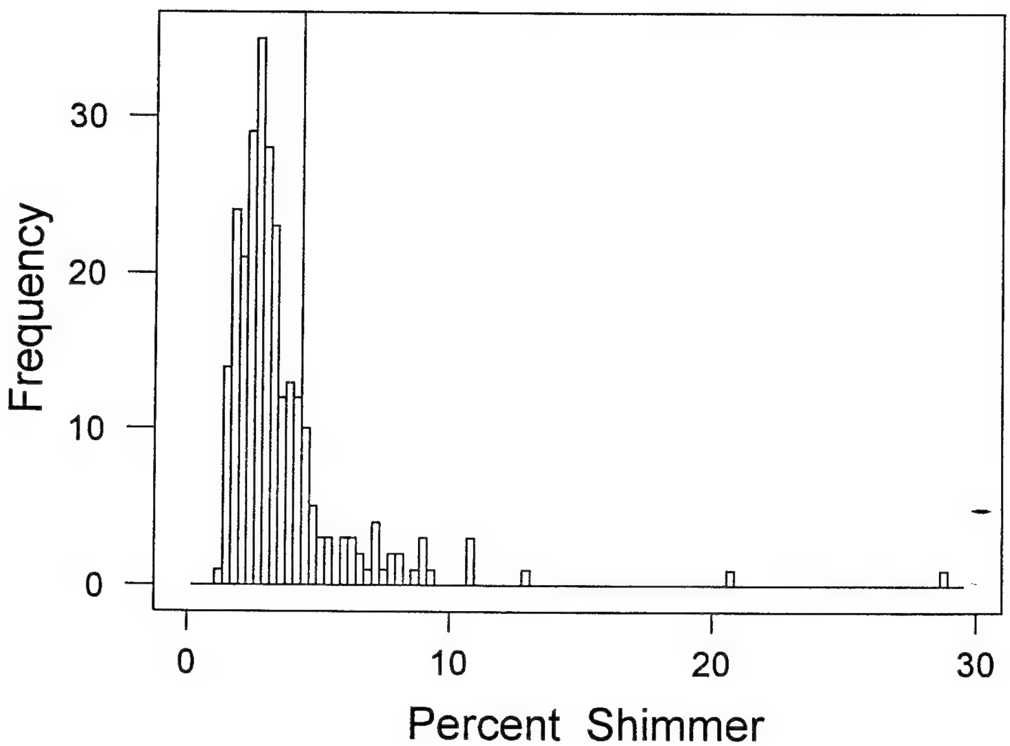

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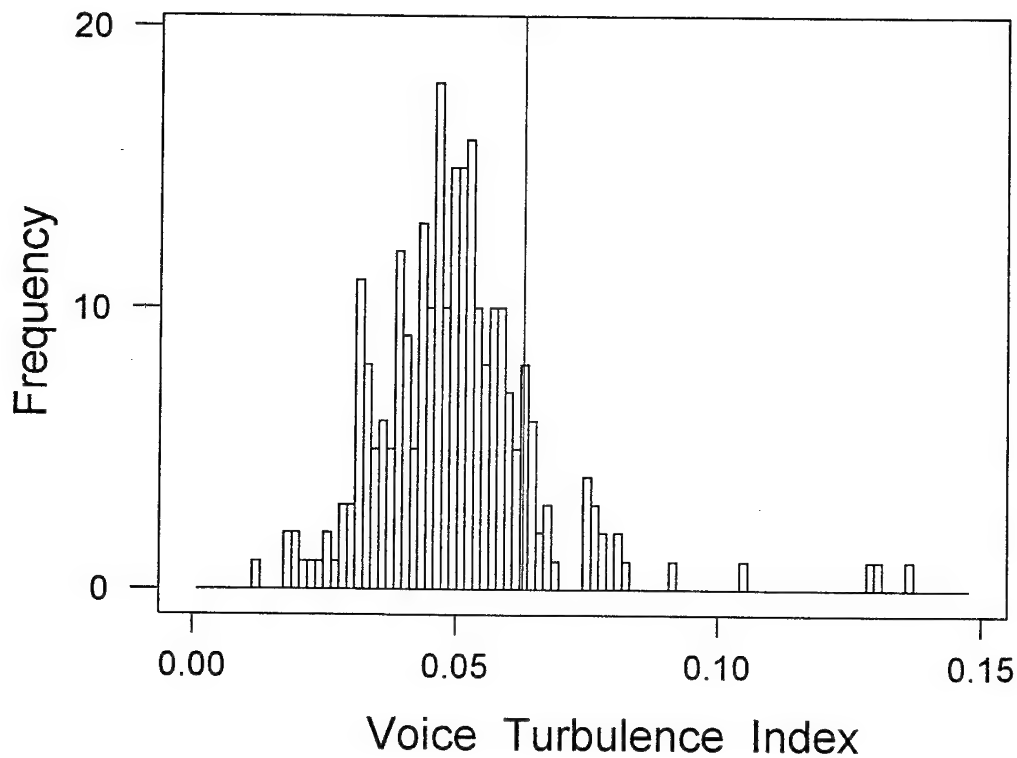
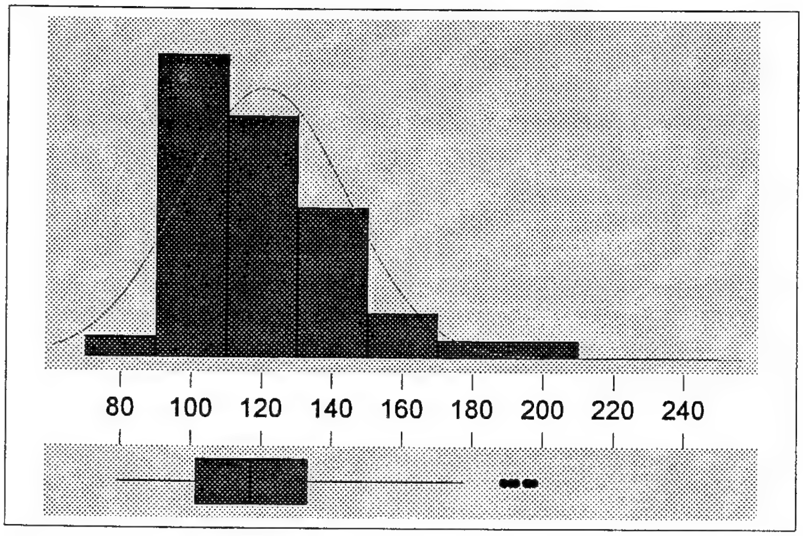
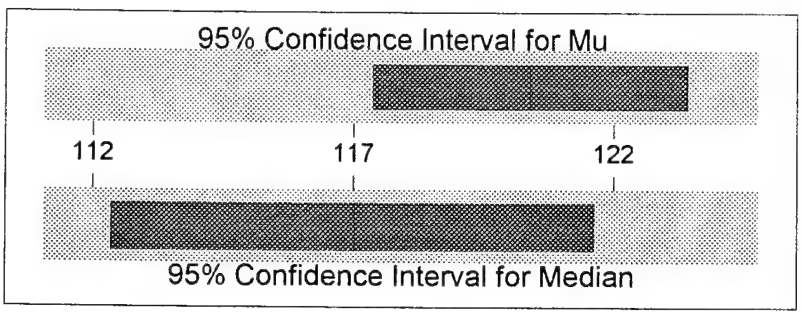


Figure 5

Descriptive Statistics





Variable: FO

Group: 1 Male

Anderson-Darling Normality Test

A-Squared:	4.392
p-value:	0.000
Mean	120.393
Std Dev	23.423
Variance	548.657
Skewness	1.086
Kurtosis	1.155
n of data	233.000
Minimum	79.284
1st Quartile	101.396
Median	117.013
3rd Quartile	133.140
Maximum	197.650

95% Confidence Interval for Mu

117.370	123.417

95% Confidence Interval for Sigma

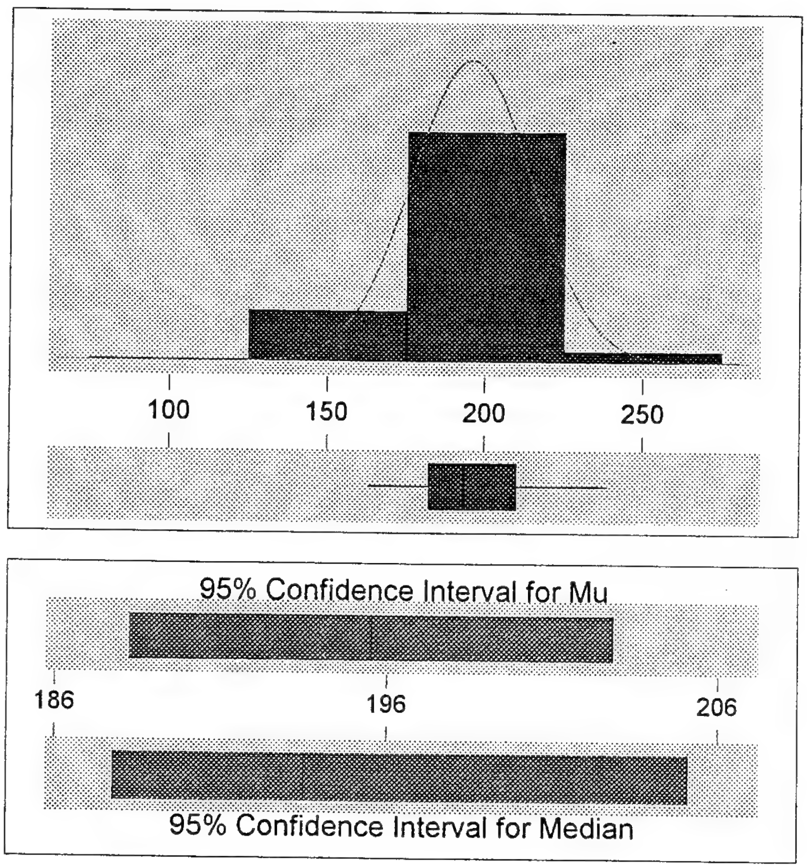
21.472	25.768

95% Confidence Interval for Median

112.323	121.626

Figure 6

Descriptive Statistics



Variable: FO

Group: 0 Female

Anderson-Darling Normality Test

A-Squared:	0.251
p-value:	0.716

Mean	195.514
Std Dev	19.166
Variance	367.351
Skewness	0.177
Kurtosis	-0.693
n of data	29.000

Minimum	163.388
1st Quartile	182.430
Median	193.491
3rd Quartile	210.257
Maximum	238.794

95% Confidence Interval for Mu

188.223	202.804

95% Confidence Interval for Sigma

15.210	25.922

95% Confidence Interval for Median

187.720	205.083

Figure 7

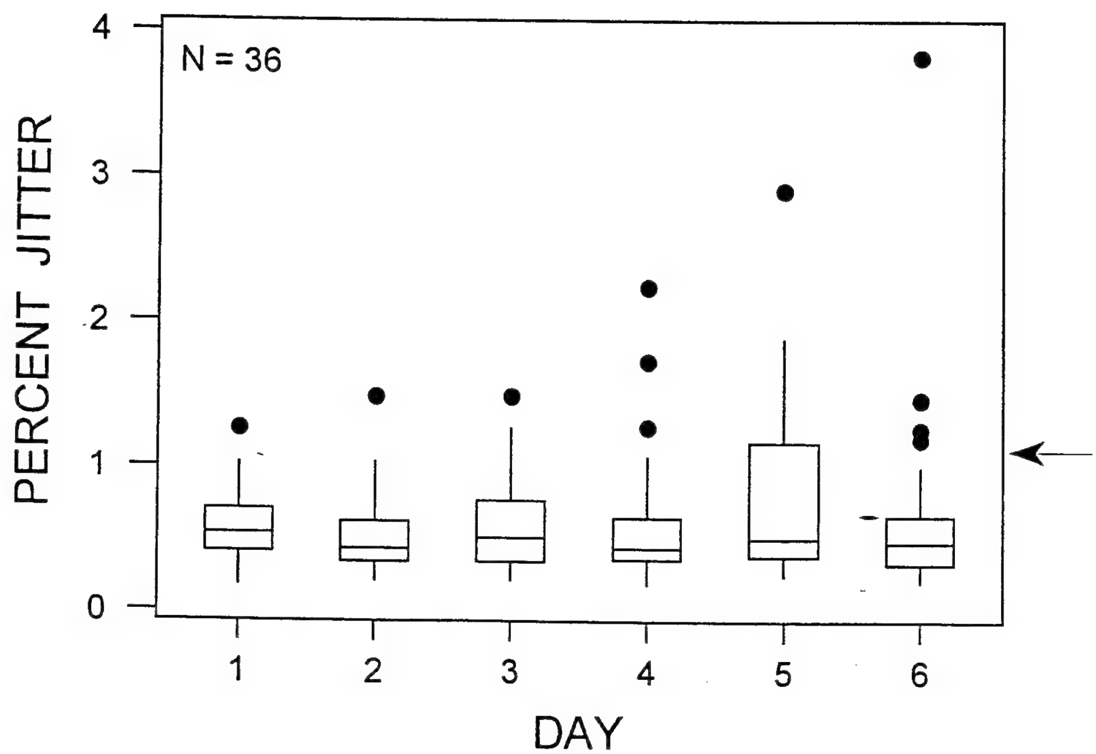


Figure 8

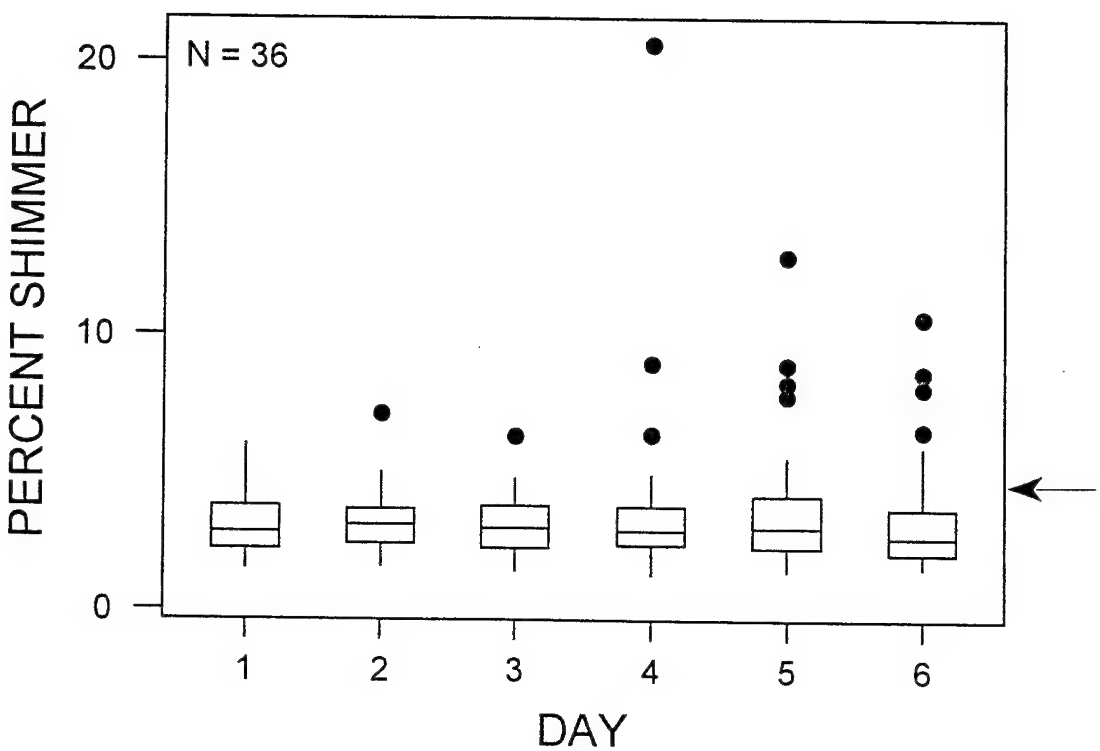


Figure 9

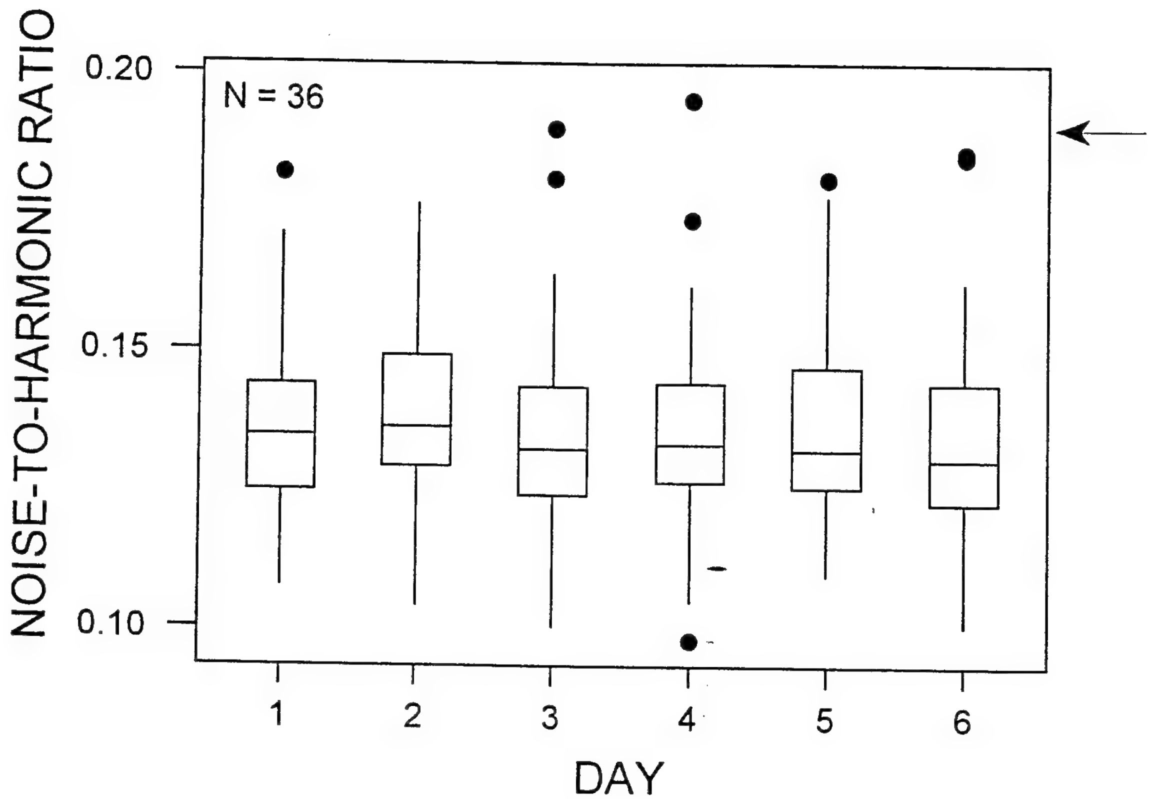


Figure 10

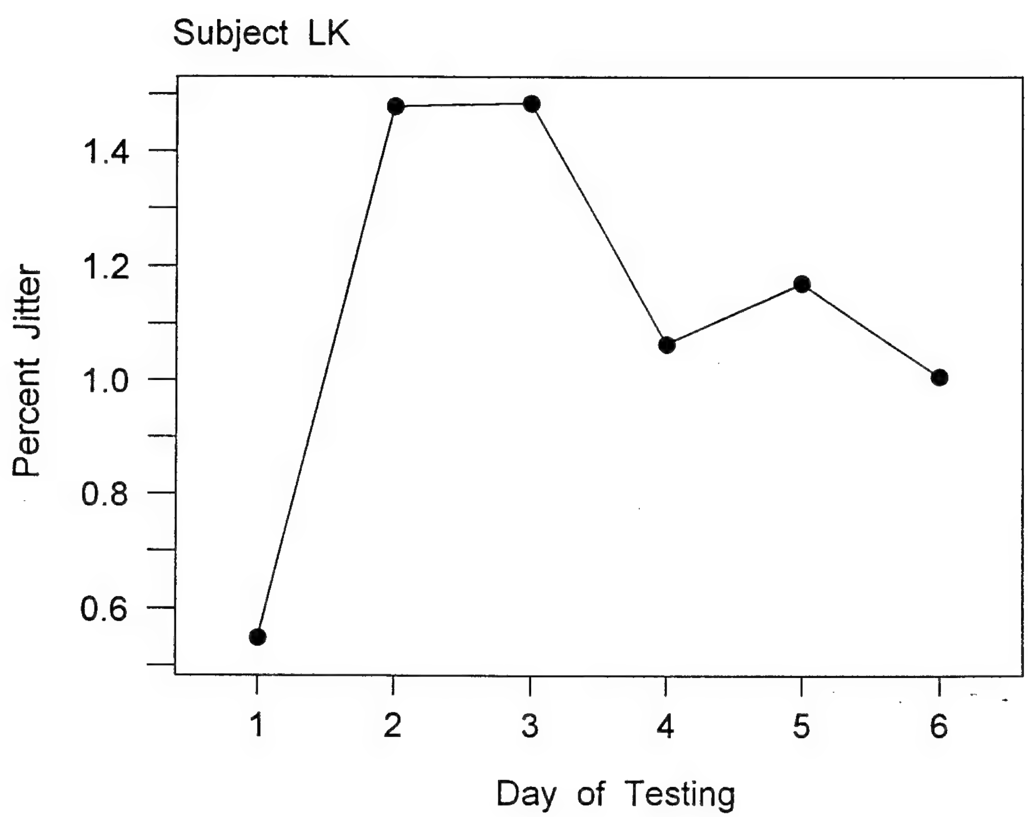

Subject LK
Percent Jitter
1.4
1.2
1.0
0.8
0.6
1
2
3
4
5
6
Day of Testing

Figure 11

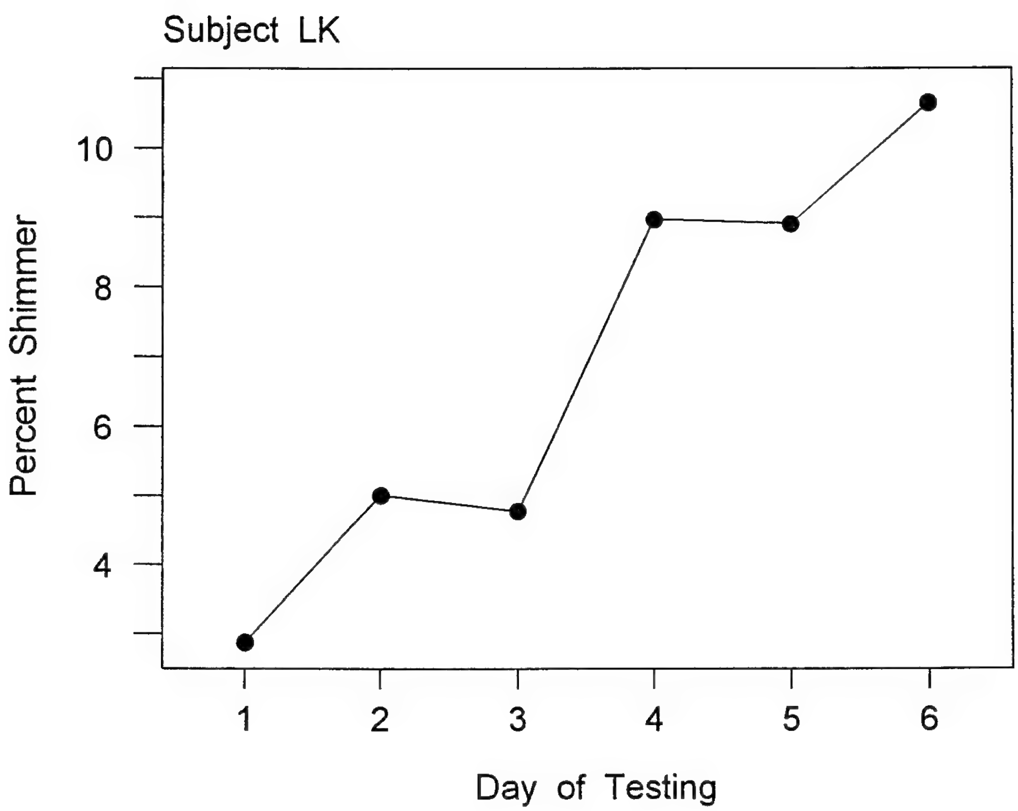


Figure 12

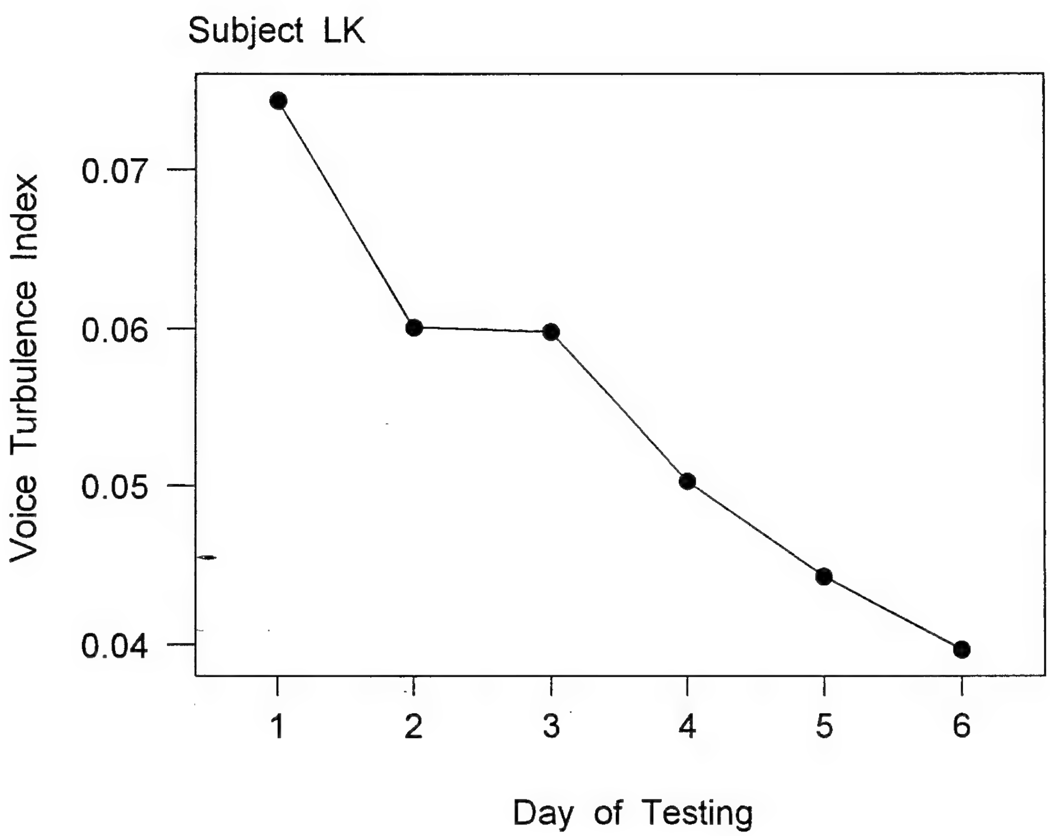

Subject LK
Voice Turbulence Index
0.07
0.06
0.05
0.04
1
2
3
4
5
6
Day of Testing

Table I

Correlations (Pearson)

	FFTR	FATR	JITT	PPQ	VFO	SHIM	APQ	VAM
FATR	0.293							
JITT	0.542	0.351						
PPQ	0.516	0.330	0.993					
VFO	0.392	0.201	0.712	0.703				
SHIM	0.411	0.482	0.603	0.577	0.535			
APQ	0.373	0.497	0.581	0.566	0.543	0.969		
VAM	0.076	0.210	0.188	0.171	0.252	0.353	0.442	
NHR	0.294	0.325	0.448	0.431	0.475	0.742	0.716	0.240
VTI	0.246	0.262	0.383	0.382	0.323	0.450	0.435	0.078
SPI	-0.132	-0.136	-0.050	-0.052	-0.080	-0.105	-0.130	-0.084
FTRI	0.164	0.013	0.204	0.217	0.468	0.144	0.183	0.150
ATRI	0.069	0.395	0.250	0.245	0.323	0.405	0.539	0.859

	NHR	VTI	SPI	FTRI
VTI	0.468			
SPI	-0.200	-0.326		
FTRI	0.186	0.076	-0.029	
ATRI	0.262	0.180	-0.129	0.280

Table II

```
MTB > GLM 'JITT' 'SHIM' 'VTI' = DAY SMOKING RATING;
SUBC>   Test DAY RATING SMOKING / Error;
SUBC>   Means DAY RATING SMOKING.
```

General Linear Model

Factor	Levels	Values					
DAY	6	1	2	3	4	5	6
SMOKING	2	0	1				
RATING	3	1	2	3			

Analysis of Variance for JITT

Source	DF	Seq SS	Adj SS	Adj MS	F	P
DAY	5	1.3998	1.7893	0.3579	1.32	0.255
SMOKING	1	1.1945	1.3532	1.3532	5.00	0.026
RATING	2	0.6203	0.6203	0.3102	1.15	0.319
Error	250	67.6233	67.6233	0.2705		
Total	258	70.8380				

Unusual Observations for JITT

Obs.	JITT	Fit	Stdev.Fit	Residual	St.Resid
4	1.72700	0.61918	0.09900	1.10782	2.17R
27	2.35500	0.80903	0.11720	1.54597	3.05R
34	2.23700	0.71387	0.09634	1.52313	2.98R
119	1.88800	0.58946	0.10495	1.29854	2.55R
131	2.90500	0.82998	0.09553	2.07502	4.06R
183	2.34000	0.66318	0.11293	1.67682	3.30R
184	1.59600	0.56802	0.09863	1.02798	2.01R
223	2.16000	0.67433	0.08574	1.48567	2.90R
246	3.82100	0.78599	0.09405	3.03501	5.93R
247	3.43700	0.91485	0.11078	2.52215	4.96R
252	2.87700	0.78599	0.09405	2.09101	4.09R
261	2.32100	0.61540	0.09000	1.70560	3.33R

R denotes an obs. with a large st. resid.

F-test with denominator: Error
Denominator MS = 0.27049 with 250 degrees of freedom

Numerator	DF	Seq MS	F	P
DAY	5	0.2800	1.03	0.398
RATING	2	0.3102	1.15	0.319
SMOKING	1	1.1945	4.42	0.037

Analysis of Variance for SHIM

Source	DF	Seq SS	Adj SS	Adj MS	F	P
DAY	5	12.945	24.590	4.918	0.69	0.629
SMOKING	1	32.294	35.227	35.227	4.96	0.027
RATING	2	14.891	14.891	7.445	1.05	0.352
Error	250	1774.103	1774.103	7.096		
Total	258	1834.233				

Unusual Observations for SHIM

Obs.	SHIM	Fit	Stdev.Fit	Residual	St.Resid
4	20.6220	3.5954	0.5071	17.0266	6.51R
5	12.8980	3.6640	0.5235	9.2340	3.54R
76	8.9720	3.4648	0.5212	5.5072	2.11R
77	8.9090	3.5335	0.5132	5.3755	2.06R
78	10.6540	3.3216	0.5414	7.3324	2.81R
223	9.4240	3.5669	0.4392	5.8571	2.23R

247	28.8730	4.8559	0.5674	24.0171	9.23R
248	10.7140	3.9704	0.4571	6.7436	2.57R
260	10.6730	3.2263	0.4624	7.4467	2.84R

R denotes an obs. with a large st. resid.

F-test with denominator: Error
Denominator MS = 7.0964 with 250 degrees of freedom

Numerator	DF	Seq MS	F	P
DAY	5	2.589	0.36	0.872
RATING	2	7.445	1.05	0.352
SMOKING	1	32.294	4.55	0.034

Analysis of Variance for VTI

Source	DF	Seq SS	Adj SS	Adj MS	F	P
DAY	5	0.0015482	0.0026772	0.0005354	2.21	0.053
SMOKING	1	0.0017275	0.0018858	0.0018858	7.80	0.006
RATING	2	0.0021146	0.0021146	0.0010573	4.37	0.014
Error	250	0.0604373	0.0604373	0.0002417		
Total	258	0.0658275				

Unusual Observations for VTI

Obs.	VTI	Fit	Stdev.Fit	Residual	St.Resid
18	0.078200	0.039360	0.002965	0.038840	2.54R
23	0.131000	0.054338	0.003147	0.076662	5.03R
70	0.020000	0.051080	0.002949	-0.031080	-2.04R
177	0.082700	0.049950	0.002631	0.032750	2.14R
212	0.012200	0.049324	0.003060	-0.037124	-2.44R
247	0.128500	0.060670	0.003312	0.067830	4.47R
248	0.104600	0.056403	0.002668	0.048197	3.15R
249	0.081500	0.049950	0.002631	0.031550	2.06R
250	0.136400	0.056524	0.002880	0.079876	5.23R
261	0.092100	0.044505	0.002691	0.047595	3.11R

R denotes an obs. with a large st. resid.

F-test with denominator: Error
Denominator MS = 0.00024175 with 250 degrees of freedom

Numerator	DF	Seq MS	F	P
DAY	5	0.000310	1.28	0.273
RATING	2	0.001057	4.37	0.014
SMOKING	1	0.001727	7.15	0.008

Means

	.... JITT		.... SHIM		.... VTI	
DAY	Mean	Stdev	Mean	Stdev	Mean	Stdev
1	0.82630	0.089758	4.32513	0.459741	0.05515	0.002683
2	0.54499	0.082552	3.43968	0.422833	0.05088	0.002468
3	0.67269	0.084691	3.21971	0.433787	0.04443	0.002532
4	0.62531	0.079324	3.60945	0.406297	0.05100	0.002371
5	0.74143	0.079539	3.67805	0.407398	0.05014	0.002378
6	0.69744	0.078950	3.46619	0.404382	0.04636	0.002360
RATING						
1	0.60564	0.058236	3.23691	0.298286	0.04538	0.001741
2	0.70033	0.051235	3.78170	0.262426	0.05246	0.001532
3	0.74811	0.077202	3.85050	0.395431	0.05114	0.002308
SMOKING						
0	0.61177	0.046726	3.25097	0.239332	0.04694	0.001397
1	0.75761	0.048265	3.99510	0.247213	0.05238	0.001443

Vocal Cord Function and Voice Quality Evaluation of Active Duty U.S. Army Drill Instructors
PARTICIPANT QUESTIONNAIRE

NAME ______________________ SSN _____-____-_____

	YES	NO	EXPLAIN
1. Do you have a history of any of the following?			
a. Vocal cord surgery	___	___	____________
b. Documented vocal cord disorder	___	___	____________
c. Recurrent hoarseness If yes, how frequently? __________	___	___	____________
d. Asthma	___	___	____________
e. Tuberculosis	___	___	____________
f. PPD conversion (TB test)	___	___	____________
g. Thyroid disorders	___	___	____________
h. Allergies If yes, what types? __________ ____________________ ____________________	___	___	____________
i. Frequent "colds"	___	___	____________
j. Current "cold"	___	___	____________
k. Smoking If previously, how many years did you smoke? _______ How many packs/day? _______ If currently, how many years have you smoked? _______ How many packs/day? _______	___	___	____________
l. Use of any other tobacco products (such as chewing tobacco, snuff)	___	___	____________
2. Do you take any medications daily? If yes, please list each medication - ____________________ ____________________ ____________________	___	___	____________
3. Do you take any over-the-counter drugs? (such as aspirin, motrin, etc.) If yes, please list each medication - __________ ____________________	___	___	____________
4. Have you used aspirin in last 10 days?	___	___	____________
5. Is this a new assignment? If not a new assignment, how long have you been a drill instructor? __________	___	___	____________

6. Do you have problems with heartburn, acid indigestion, frequent sour taste in your mouth, etc.?
   ___yes ____no If so, what treatments do you use? (for example, antacids, medications)

7. Do you have any swallowing problems? If so please explain:

8. Do you eat or drink caffiene rich foods (coffee, tea, soft drinks, chocolate)? If so, please quantify how much in a typical day (how many cups of coffee, how much chocolate):

Appendix II

VOICE QUESTIONNAIRE FORM

Name_________________
SSN#__________ MOS________________
Sex:__Male __Female AGE_____ DATE OF BIRTH__________
Number of consecutive years in the military________________
Number of consecutive years as a U.S. Army Drill Instructor________

IMPORTANT INSTRUCTIONS FOR FILLING OUT THIS FORM:

A. PLEASE GIVE INFORMATION ABOUT YOUR **PRESENT** VOICE CHARACTERISTICS.

B. SOMETIMES YOU WILL BE ASKED TO CHECK OFF ITEMS AND OTHER TIMES YOU WILL BE ASKED TO GIVE A WRITTEN DESCRIPTION OF YOUR VOICE OR VOICE BEHAVIORS.

C. PLEASE ASK ONE OF THE EXAMINERS QUESTIONS IF YOU ARE NOT SURE HOW TO COMPLETE THIS FORM.

1. How would you describe your present voice ?

VOICE QUALITY (how good does your voice sound)

___hoarse or raspy
___breathy
___sudden interruption of voicing or voice stoppage
___strain/struggle voice
___tremor (to include a wobbly/shakey voice)
___periods of total voice loss
___a nasal voice quality (air escaping through your nose during voice use)
___a stuffy voice (a cold in the nose voice quality)
___normal voice quality

PITCH (the rise and fall of your voice)

___pitch breaks (voice uncontrollably jumps higher and lower)
___inappropriate or excessively low pitch
___inappropriate or excessively high pitch
___reduced pitch range
___monopitch (no pitch variation)
___inadequate pitch range for professional singing
___adequate pitch level for voice use
___adequate pitch range for professional and recreational singing

LOUDNESS (the volume of your voice)

___loudness level is too loud
___loudness level is too soft
___whispering on purpose
___uncontrolled whispering
___sudden or gradual,uncontrollable drop in loudness level
___lack of ability to vary loudness at will
___monoloudness (no loudness variation)
___inadequate loudness for professional singing
___an adequate loudness level for daily voice activities
___adequate loudness for profession or recreational singing

2.How would you describe your present speech characteristics?

PLEASE CHECK ALL SPEECH CHARACTERISTICS THAT APPLY TO YOU:

___people understand my speech at all times

people ask me to repeat myself:
never___frequently___constantly___

people say that my speech sounds:
___slurred
___I have difficulty saying the following speech sounds or words:
____
____

3. How would you describe your breathing pattern for voice use?

PLEASE CHECK THE PRIMARY BREATHING CHARACTERISTICS THAT APPLY TO YOU:

My breathing pattern during my drill instructor activities is typically characterized by:
___full chest breaths
___shallow chest breaths
___a rapid breath rate
___irregular breaths
___audible or noisy inhalations
___use of the diaphragm or abdominal muscles
___I experience shortness of breath while instructing

4. Does the quality, pitch and/or loudness of your voice change during the course of your day while you are engaged in your drill instructor activities? ___yes ____no

IF YES PLEASE CHECK ALL THAT APPLY

___I experience voice problems before I start instructing
___within 15 minutes of instruction
___within 30 minutes of instruction
___withing 60 minutes of instruction
___within 90 minutes of instruction
___within 120 minutes of instruction
___by mid-day
___by mid-afternoon
___by end of day___
___ All other times on or off duty please specify:______________________________
____

5. I notice that my voice typically changes (becomes hoarse, breathy, voice loss etc.) when I use my voice during the following drill instructor activities:
PLEASE CHECK ALL THAT APPLY:

__Barracks inspection
__Physical fitness exercise classes
__Calling cadence while marching
__Calling cadence while running
__Singing cadence while running
__Classroom instruction indoors without amplification
__Classroom instruction on the field without amplication
__Weapons qualification with background noise
__Instruction on the rifle range
__Instruction on the grenade range
__Night firing instruction
__Other drill activities(please list):____
____
____

6. When my voice changes or my throat hurts I do the following to help myself recover:

PLEASE CHECK ALL THAT APPLY:

__Voice rest
__Use a higher pitch
__Use a lower pitch
__Whisper
__Gargle
__Use lozenges
__Use a bull horn or other amplification
__Throat clearing
__Coughing
__Strain my voice to try and maintain my voice
__I do not do anything differently
__Other self help behavoirs (please list)________________________

____

____

7. If you suffer from voice changes, voice loss, voice fatigue or voice pain as a result of drill instructing how long does it take your voice to feel or sound normal to you again?

__after being off duty 1-3 hours
__after being off duty 3-6 hours
__by the next morning before drill instruction begins
__after being off duty one day
__after being off duty two days
__after being off duty three days
__if longer than three days please specify the number of days or weeks:

____

____

8. Were you instructed on how to use a COMMAND VOICE for drill instructing? If the answer is yes, when and where did you receive this instruction please specify:____

____

9. Please list all of the COMMAND VOICE TRAINING suggestions that you STILL USE NOW when training new recruits: PLEASE BE SPECIFIC AND ABOUT WHAT YOU WERE TAUGHT THAT YOU STILL USE NOW:

____

____

10. How do you adjust the loudness or volume of your voice so that all the soldiers in your unit can hear you?________________________________

____

11. How do you use your breathing for a COMMAND VOICE? ____________

____

12. How do you adjust your posture to assure a COMMAND VOICE? _______

____

13. How do you use the rise and fall of your pitch for a COMMAND VOICE ?

____

14. Have you had an ENT Evaluation because of voice problems since you have been a drill instructor? If yes, give the month and year & state what you were told about your voice and the treatment you received.

____

____

15. Have you had a Voice Evaluation because of voice problems since you have been a drill instructor? If yes, give month and year and state what you were told about your voice?______________________

____

____

16. Have you had voice therapy for a voice problem since you have been a drill instructor? If yes, please decribe what you worked on:

____

____

17. Did your voice improve with voice therapy? Yes____ No______

PRODUCE THE FOLLOWING SPEECH SAMPLE INTO THE MICROPHONE. THEN PROVIDE THE REQUESTED INFORMATION. USE A VOICE THAT IS COMFORTABLE FOR YOU, AND MAINTAIN A CONSTANT HEAD POSITION.

SPEECH SAMPLE

"ah" (for about 5 seconds)

"The top of the pot is very hot."

1. Name

2. Last four digits of you Social Security No.

3. Today's data and the time

4. Your vocal abuse rating for the previous three hour period

WALTER REED RATING SCALE PROPOSAL

Subject #_______
Rater :_______
Pitch Level:______

1. VOCAL FOLD CLOSURE

0	1	2
Underclosure	Complete	Overclosure

2. GLOTTAL GAP

0	1	2
Anterior Gapping	Within Normal Limits	Posterior Gapping

3. VOCAL FOLD EDGES

	0	1	2
LEFT	0	1	2
	Smooth/Straight		Rough/Irregular
RIGHT	0	1	2

4. HOURGLASS CONFIGURATION

0	1	2
Absent		Present

5. AMPLITUDE OF EXCURSION

LEFT	0	1	2
	Normal		Absent
RIGHT	0	1	2

6. MUCOSAL WAVE

LEFT	0	1	2
	Normal		Absent
RIGHT	0	1	2

7. PHASE SYMMETRY

LEFT	0	1	2
	Regular		Always Irregular
RIGHT	0	1	2

8. EDEMA

LEFT	0	1	2
	Absent		Severe
RIGHT	0	1	2

9. ERYTHEMA/REDNESS

LEFT	0	1	2
	Absent		Severe
RIGHT	0	1	2

Video Quality: Best Fine Poor

MULTI-DIMENSIONAL VOICE PROGRAM Model 4305

Kay Elemetrics Corp.

ENTERING THE MDVP PROGRAM

1. Make sure that the MDVP program has been properly installed. Place the keyboard overlay on the computer keyboard to facilitate quick operation.
2. Turn on the monitor, computer system and external CSL module.
3. Type MDVP after the DOS prompt.

CAPTURING AND ANALYZING DATA

1. Select CAPTURE on the Main Menu and then "Set for Sustained Phonation".
2. Instruct the client to hold the microphone at a relatively fixed distance (2-6 inches) from the mouth.
3. Press the [F1] key to initiate signal capture.
4. Have the client sustain an open "ah" vowel in a flat tone at a comfortable pitch and at a constant amplitude. Adjust the input level to obtain a nearly full scale level without overloading.
5. After the input level has been adjusted, record a full screen of information (3 seconds) before halting data capture. Press any key or the mouse button to stop capturing before the client stops vocalizing.
6. If the data is acceptable, press the [F7] key to perform the analysis and review the results. If unacceptable press the [F2] key to purge and repeat Steps 1-4.

NOTE FOR MULTI-CHANNEL RECORDING: MDVP currently supports only 1 or 2 channel recording.

7. Press the [F9] key to review the graph comparing the client's production (red/brown) to the database of normative thresholds (green circle). Values which are red and outside the circle are higher (worse) than the threshold.
8. Select the HELP box and then use the mouse to select any parameter to get an explanation of that parameter.
9. Press the ESC key to exit the graph.
10. Press [F8] to see the statistics. Use the up and down arrow keys next to scroll bars to see other analysis parameters. Select OK to exit statistics display.
11. Select view A. Press [F3] to listen to the signal. Repeat twice with each client.

FUNCTION KEYS

[F1]	Capture One Channel
[F2]	Purge Active View Screen
[F3]	Speak All
[F4]	Speak Marked
[F5]	Load User File
[F6]	Save a File
[F7]	Voicing Macro
[F8]	Show Numerical Analysis
[F9]	Show Diagram
[F10]	Load User Setup

INTERPRETING THE ANALYSIS RESULTS

The eight groups of analysis are as follows:

1. Fundamental Frequency Information Measurements
2. Short and Long-Term Frequency Perturbation Measurements
3. Short and Long-Term Amplitude Perturbation Measurements
4. Voice Break Related Measurements
5. Sub-Harmonic Components Related Measurements
6. Voice Irregularity Related Measurements
7. Noise Related Measurements
8. Tremor Related Measurements

MDVP EXTRACTED PARAMETERS - Alphabetical Listing (continued on back)

Sym	Unit	Description	Thres
APQ	%	Amplitude Perturbation Quotient gives an evaluation of the variability of the peak-to-peak amplitude within the analyzed voice sample at smoothing factor 11 periods.	3.07
ATRI	%	Amplitude Tremor Intensity Index shows in percent the ratio of the amplitude of the most intensive low frequency amplitude modulating component (amplitude tremor) to the total amplitude of the analyzed voice signal.	4.37*
DSH	%	Degree of Sub-Harmonics is an estimated relative evaluation of sub-harmonic to Fo components in the voice sample.	1.00†*
DUV	%	Degree of Voiceless is an estimated relative evaluation of nonharmonic areas (where Fo cannot be detected) in the voice sample. In case of nonsustained phonation from the beginning to the end of the data acquisition, DUV will evaluate also the pauses before, after and/or between the voice sample(s).	1.00†*
DVB	%	Degree of Voice Breaks shows in percent the ratio of the total length of areas representing voice breaks to the time of the complete voice sample.	1.00†*
Fatr	Hz	Amplitude Tremor Frequency shows the frequency of the most intensive low frequency component in the specified range. If the corresponding ATRI value is below the specified threshold, the Fatr value will not be computed.	N.A.
Fftr	Hz	Fo Tremor Frequency shows the frequency of the most intensive low frequency component in the specified range. If the corresponding FTRI value is below the specified threshold, the Fftr value will not be computed.	N.A.
Fhi	Hz	Highest Fundamental Frequency for all extracted pitch periods.	N.A.
Flo	Hz	Lowest Fundamental Frequency for all extracted pitch periods.	N.A.
Fo	Hz	Average Fundamental Frequency for all extracted pitch periods.	N.A.
FTRI	%	Fo Tremor Intensity Index shows in percent the ratio of the frequency magnitude of the most intensive low frequency modulating component (Fo tremor) to the total frequency magnitude of the analyzed voice signal.	0.95*
Jita	us	Absolute Jitter gives an evaluation of the period-to-period variability of the pitch period within the analyzed voice sample.	83.2

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MDVP EXTRACTED PARAMETERS - Alphabetical Listing (continued)

Sym	Unit	Description	Thres
Jitt	%	Jitter Percent gives an evaluation of the variability of the pitch period within the analyzed voice sample. It represents the relative period-to-period (very short term) variability.	1.04
NHR		Noise-to-Harmonic Ratio is an average ratio of energy of the inharmonic components in the range 1500-4500 Hz to the harmonic components energy in the range 70-4500 Hz. It is a general evaluation of the noise presence in the analyzed signal (such as amplitude and frequency variations, turbulence noise, sub-harmonic components and/or voice breaks).	0.19*
NSH		Number of Sub-Harmonic Segments found during analysis.	0.90†*
NUV		Number of Unvoiced Segments detected during the autocorrelation analysis.	0.90†*
NVB		Number of Voice Breaks shows how many times the generated Fo was interrupted from the beginning of the first until the end of the last voiced area.	0.90†*
PER		Pitch Periods detected during the period-to-period pitch extraction.	N.A.
PFR	Semi-Tones	Phonatory Fundamental Frequency Range the range between Fhi and Flo expressed in number of semi-tones.	N.A.
PPQ	%	Pitch Period Perturbation Quotient gives an evaluation of the variability of the pitch period within the analyzed voice sample at smoothing factor 5 periods.	0.84
RAP	%	Relative Average Perturbation gives an evaluation of the variability of the pitch period within the analyzed voice sample at smoothing factor 3 periods.	0.68
sAPQ	%	Smoothed Amplitude Perturbation Quotient gives an evaluation of the short or long term variability of the peak-to-peak amplitude within the analyzed voice sample. The smoothing factor can be defined by the user. For example, at smoothing factor 1 (no smoothing), sAPQ is identical to Shim at smoothing factor 11 to APQ. At high smoothing factors (55 and above), sAPQ correlates with the intensity of the long term peak-to-peak amplitude variations, such as amplitude tremors. The sAPQ smoothing factory setup is 55.	4.23*
SEG		Total Number of Segments computed during the autocorrelation analysis.	N.A.
ShdB	dB	Shimmer in dB gives an evaluation of the period-to-period variability of the peak-to-peak amplitude within the analyzed voice sample.	0.35
Shim	%	Shimmer Percent gives an evaluation of the variability of the peak-to-peak amplitude within the analyzed voice sample. It represents the relative period-to-period (very short term) variability of the peak-to-peak amplitude.	3.81

*NOTE: Parameters with an asterisk under Norm Thres have not been reported on extensively in the literature. Threshold values, while computed on both normal and disordered voices, should be viewed as preliminary.

Sym	Unit	Description	Thres
SPI		This parameter is not actually a measurement of noise, but rather the harmonic structure of the spectrum. Soft Phonation Index is an average ratio of the lower frequency harmonic energy (70-1600 Hz) to the higher frequency (1600-4500 Hz) harmonic energy (compare to NHR and VTI). Increased value of SPI may be an indication of incomplete or loosely adducted vocal folds during phonation. SPI is very sensitive to the vowel formant structure, because vowels with lower high frequency energy will result in higher SPI. Only values computed for the same vowel can be compared. The vowel /a/ is recommended.	14.12*
sPPQ	%	Smoothed Pitch Period Perturbation Quotient gives an evaluation of the short or long term variability of the pitch period within the analyzed voice sample. The smoothing factor can be defined by the user. For example, at smoothing factor 1 (no smoothing), sPPQ is identical to Jitt at smoothing factor 5 to PPQ. At high smoothing factors (55 and above), sPPQ correlates with the intensity of the long term pitch period variations, such as frequency tremors. The sPPQ smoothing factory setup is 55.	1.02*
STD	Hz	Standard Deviation of the Fundamental Frequency within the analyzed voice sample.	N.A.
To	ms	Average Pitch Period for all extracted pitch periods.	N.A.
Tsam	sec	Length of Analyzed Data Sample.	N.A.
vAm	%	Peak Amplitude Variation represents the relative standard deviation of the period-to-period calculated peak-to-peak amplitude. It reflects the very long term amplitude variations within the analyzed voice sample.	8.20
vFo	%	Fundamental Frequency Variation represents the relative standard deviation of the period-to-period calculated fundamental frequency. It reflects the very long term variations of Fo for all the analyzed voice sample.	1.10
VTI		Voice Turbulence Index is an average ratio of the spectral inharmonic high frequency energy in the range 2800-5800 Hz to the spectral harmonic energy in the range 70-4500 Hz in areas of the signal where the influence of the frequency and amplitude variations, voice breaks and sub-harmonic components are minimal. VTI measures the relative energy level of high frequency noise. It mostly correlates with the turbulence caused by incomplete or loose adduction of the vocal folds.	0.061*

†NOTE: The values of 1.00 and 0.90 are provided for graphic scaling only. The actual value in all cases is 0.00 since any voice break (DVB), for example, is not normal. Any presence of voiced breaks (DBV), sub-harmonics (DSH), etc. are plotted outside normal threshold values on the graph.

Appendix VI

Suggested Lesson Plan Outlines

I. Anatomy and Physiology of the Vocal Tract (Respiratory, Phonatory, Articulatory, and Resonatory Systems)

A. Written materials to supplement the current NCO Manual FM 22, Chapter 1. Section II and Glossary

1. Learning-interactive notebook for each student

a. anatomic diagrams of the larynx, diaphragm, vocal tract

b. systematic description of each system followed by completion of written answers to questions of each section

2. Instruction on the adverse impact of various behaviors on voice

a. Smoking

b. Excessive caffeine ingestion

c. Gastroesophageal reflux

d. Dehydration

B. Classroom review and clarification of notebook sections supplemented by audiovisual aids by course instructor

II. Impact of Stress on Vocal Performance and Review of Tension Reduction Techniques

A. Identify D.I. situations that increase stress level, i.e., need for excessive redundancy in instructing new recruits.

B. Supplemental materials and discussion to illustrate how stress increases laryngeal and neck muscle tension which may impair vocal performance

C. Instruct students to increase their awareness of body tension vs. body relaxation

D. Teach progressive relaxation exercises

III. Introduction to Diaphragmatic Muscle Control

A. Instruction/Demonstration of Respiratory System with focus on location and function of the diaphragm.

1. Use of life size visual aids of anatomy

2. Instruct students how to locate diaphragmatic muscles on themselves

3. Instruct correct vs. incorrect support and control of muscles

4. Instruct/demonstrate appropriate posture to facilitate proper breath control

B. Student Practice

1. In small groups without voice use

2. Purposeful correct and purposeful incorrect breathing (negative practice)

3. Emphasis on soldiers self-monitoring/ self-correction

IV. Diaphragmatic Control Coordinated with Voice Production (emphasis on diaphragm as power source for voice production)

A. Instruct/demonstrate correct breath-voice coordination patterns (i.e., "the best voice with the least amount of effort")

B. Instruct/demonstrate correct vs. incorrect behavior patterns

1. recognize visible and audible signs of laryngeal strain (bulging neck muscles, postural shift forward, roughened voice quality)

C. Student's purposeful practice of correct vs. incorrect behavior immediately following instructor demonstration in small groups

D. Instructor adds complexity of commands to tasks

E. Student practice as above

V. Voice Projection/Instruction/Demonstration/Practice

A. Instruction/demonstration on how to place voice from varying distances

1. Visual voice targets instructions

2. Progressive placement instruction up maximum goal of 40 ft.

B. Student Practice in varying environments (indoor/outdoor/platform)

VI. Distinctiveness- clear precise speech while giving commands

A. Emphasis on exaggerated mouth movements to aid voice projection and open relaxed throat during voicing

B. Emphasis on precise, definite articulation of the final sounds of words in command to ensure crisp, clear speech

C. Student practice immediately following above instruction

VII. Inflection of Voice / Cadence

A. Instructor definition/demonstration of "the natural speaking voice" and a variety of commands

B. Correct vs. Incorrect models with information on how use of unnatural pitch can cause vocal strain or injury

C. Instruction/demonstration of "inflection with snap"

D. Student practice with audio recording feedback

VIII. Maintenance of Behaviors

A. Periodic on site spot checks after completion of course to ensure proper command voice vocalization techniques are used

B. Mini "refresher" course for drill instructors who experience signs of vocal abuse behaviors and/or voice changes

BIBLIOGRAPHY

Abstract:

"Effects of Acute Vocal Abuse on Laryngeal Structure and Function" presented at the ASHA 1996 Annual Convention in Seattle, WA on November 21, 1996 by Julie Barkmire, PhD.